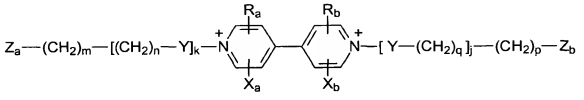
Patent claims

1. A circuit element having a first layer composed of an electrically insulating substrate material,

- having a first electrically conductive material, which is in the form of at least one discrete area such that it is embedded in the substrate material and/or is applied to the substrate material,
- a second layer having a second electrically conductive material, and
- a monomolecular layer composed of redox-active bispyridinium molecules, which is arranged between the first layer composed of the electrically insulating substrate material and the second layer with the second electrically conductive material, with the bispyridinium molecules in the monomolecular layer being immobilized on the electrically conductive material which is in the form of at least one discrete area, and with bispyridinium molecules in the monomolecular layer making electrical contact with the second electrical material of the second layer, and
- in which electrically inert molecules are immobilized on the first layer which is composed of the electrically insulating substrate material, and which molecules form a matrix which surrounds the at least one discrete area with the monomolecular layer composed of bispyridinium molecules.

2. The circuit element as claimed in claim 1, in which the bispyridinium molecules are compounds with the general formula (I),



wherein in formula (I),

one or more of the carbon atoms of the two aromatic ring systems of the bispyridinium unit can be replaced independently of one another by at least one grouping X_a or X_b which in each case represents a heteroatom which is chosen from S, N and O, or which represents a blank,

one or more of the carbon atoms of the two ring systems may, in each case independently of one another, have a substituent R_a or R_b which in each case independently represents alkyl, aryl, alkylaryl, alkenyl, alkynyl, halogen, CN, OCN, NCO, COOH, COOR', CONHR', NO_2, OH, OR', NH_2, NHR', NR'R", SH and SR', wherein R' and R" may independently of one another be alkyl, aryl, alkylaryl, alkenyl or alkynyl, or

wherein R_a and R_b may together form a bridge between the two aromatic ring systems, which bridge comprises 1 to 3 atoms, wherein the atoms are chosen independently of one another from C, S, N and O, and may be linked to one another by a single, double or triple bond and, furthermore, may have a substituent R_c, with the substituent R_c having the meaning indicated above for R_a and R_b,

Y represents a group which can be chosen independently of one another from CH_2, O, S, NH, NR', COO, CONH, CH=CH, C≡C or aryl,

Z_a and Z_b may in each case independently of one another be CH_3, -CH=CH_2, SH, -S-S-, -C(CO)CH_3, $SiCl_3$, $Si(OR)_3$, SiR(OR')(OR"), SiR(OR')$_2$, Si(R'R")NH_2, COOH, SO_3, PO_3H or NH_2, wherein R' and R" may each independently of one another be alkyl, aryl, arylalkyl, alkenyl or alkynyl,

wherein n, q may in each case independently of one another assume a value between 0 and 12,

j and k may in each case independently of one another assume a value between 0 and 6, and

p and m may in each case independently of one another assume a value between 0 and 12.

3. The circuit element as claimed in claim 1 or 2, in which the electrically inert molecules are compounds with a long-chain alkyl residue.

4. The circuit element as claimed in claim 3, in which the inert molecules have a head group by means of which they are covalently bonded to the first layer which is composed of the electrically insulating substrate material.

5. The circuit element as claimed in claim 4, in which the inert molecules are alkylsilyl compounds with the general formula

CH_3-$(CH_2)_p$-$SiR_1R_2R_3$ (II),

wherein in formula (II) p represents an integer between 1 and 30, preferably 1 and 20, and wherein R_1, R_2 and R_3 may independently of one another be hydrogen, halogen, OR', NHR', NR'R", where R' and R" is equally alkyl.

6. The circuit element as claimed in claim 1, in which a plurality of discrete areas which are composed of the first electrically conductive material are embedded in the substrate material and/or are applied to the substrate material.

7. The circuit element as claimed in claim 1, in which the first electrically conductive material is gold, silver palladium, platinum or silicon.

8. The circuit element as claimed in claim 1, in which the layer which is composed of the second electrically conductive material comprises titanium and/or aluminum.

9. The circuit element as claimed in claim 1, in which the first electrically conductive material and the second electrically conductive material are in the form of electrodes.

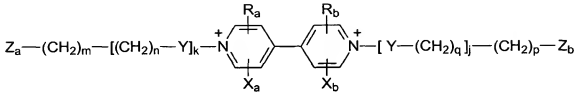
10. The circuit element as claimed in claim 9, which is a memory element.

11. The circuit element as claimed in claim 10, which is a nonvolatile memory.

12. A method for producing a circuit element, in which

- a layer composed of an insulating substrate material is provided,
- a first electrically conductive material is embedded in the substrate material and/or is applied to the substrate material at at least one discrete position,
- redox-active bispyridinium molecules are immobilized as monomolecular layer on the at least one discrete area which is composed of the first electrically conductive material,
- electrically inert molecules are immobilized on the first layer which is composed of the electrically insulating substrate material, whereby the electrically inert molecules form a matrix which surrounds the at least one area with the monomolecular layer composed of bispyridinium molecules,
- a second layer with a second electrically conductive material is applied to the layer composed of the electrically inert molecules and the bispyridinium molecules, whereby the bispyridinium molecules in the monomolecular layer make contact with the second electrical material of the second layer.

13. The method as claimed in claim 12, in which compounds with the general formula (I)



are used as bispyridinium molecules, wherein the formula (I),

one or more of the carbon atoms of the two aromatic ring systems of the bispyridinium unit can be replaced independently of one another by at least one grouping X_a or X_b which in each case represents a heteroatom which is chosen from S, N and O, or which represents a blank,

one or more of the carbon atoms of the two ring systems may, in each case independently of one another, have a substituent R_a or R_b which in each case independently represents alkyl, aryl, alkylaryl, alkenyl, alkynyl, halogen, CN, OCN, NCO, COOH, COOR', CONHR', NO_2, OH, OR', NH_2, NHR', NR'R", SH and SR', wherein R' and R" may independently of one another be alkyl, aryl, alkylaryl, alkenyl or alkynyl, or

wherein R_a and R_b may together form a bridge between the two aromatic ring systems, which bridge comprises 1 to 3 atoms, wherein the atoms are chosen independently of one another from C, S, N and O, and may be linked to one another by a single, double or triple bond and, furthermore, may have a substituent R_c, with the substituent R_c having the meaning indicated above for R_a and R_b,

Y represents a group which can be chosen independently of one another from CH_2, O, S, NH, NR', COO, CONH, CH=CH, C≡C or aryl,

Z_a and Z_b may in each case independently of one another be CH_3, -$CH{=}CH_2$, SH, -S-S-, -$C(CO)CH_3$, $SiCl_3$, $Si(OR)_3$, SiR(OR')(OR"), $SiR(OR')_2$, Si(R'R")NH_2, COOH, SO_3, PO_3H or NH_2, where R' and R" may each independently of one another be alkyl, aryl, arylalkyl, alkenyl or alkynyl,

wherein n, q may in each case independently of one another assume a value between 0 and 12,

j and k may in each case independently of one another assume a value between 0 and 6, and

p and m may in each case independently of one another assume a value between 0 and 12.

14. The method as claimed in claim 12 or 13, in which compounds with a long-chain alkyl residue are used as electrically inert molecules.

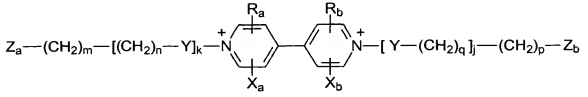
15. The method as claimed in claim 12, in which gold is used as the first conductive material.

16. The method as claimed in claim 12, in which the first electrically conductive material is embedded in and/or is applied to the substrate material in a regular pattern.

17. The method as claimed in claim 12, in which the second electrical material is vapor-deposited onto the layer composed of the electrically inert molecules and the bispyridinium molecules.

18. The method as claimed in claim 17, in which titanium and/or aluminum are/is used as the second electrically conductive material.

19. A bispyridinium compound having the general formula (Ib)



wherein in formula (Ib)

one or more of the carbon atoms of the two aromatic ring systems of the bispyridinium unit can be replaced independently of one another by at least one grouping X_a or X_b which in each case represents a heteroatom which is chosen from S, N and O, or which represents a blank,

one or more of the carbon atoms of the two ring systems, in each case independently of one another, has a substituent R_a or R_b which in each case independently represents alkyl, aryl, alkylaryl, alkenyl, alkynyl, halogen, CN, OCN, NCO, COOH, COOR', CONHR', NO_2, OH, OR', NH_2, NHR', NR'R", SH and SR', wherein R' and R" may independently of one another be alkyl, aryl, alkylaryl, alkenyl or alkynyl, or

wherein R_a and R_b together form a bridge between the two aromatic ring systems, which bridge comprises 1 to 3 atoms, wherein the atoms are chosen independently of one another from C, S, N and O, and may be linked to one another by a single, double or triple bond and, furthermore, may have a substituent R_c, with the substituent R_c having the meaning indicated above for R_a and R_b,

Y represents a group which can be chosen independently of one another from CH_2, O, S, NH, NR', COO, CONH, CH=CH, C≡C or aryl,

Z_a and Z_b may in each case independently of one another be CH_3, -CH=CH_2, SH, -S-S-, $SiCl_3$, $Si(OR)_3$, SiR(OR')(OR"), $SiR(OR')_2$, $Si(R'R")NH_2$, $Si(R_2')NH_2$, COOH, SO_3, PO_3H or NH_2, wherein R' and R" may each independently of one another be alkyl, aryl, arylalkyl, alkenyl or alkynyl,

wherein n, q may in each case independently of one another assume a value between 0 and 12,

j and k may in each case independently of one another assume a value between 0 and 6, and

p and m may in each case independently of one another assume a value between 0 and 12,

with the following compounds being excluded:

N,N'-dimethyl-4,5,9,10-tetrahydro-2,7-diazapyreniumdiiodide;
1,1',2,2'-tetramethyl-4,4'-bispyridinium;
1,1',2-trimethyl-4,4'-bispyridinium;
N,N'-dimethyl-2,7-diazapyrenium;
N-methyl-N'-(p-toloyl)-2,7-diazapyrenium,
1,1'-dimethyl-2-phenyl-6-(p-toloyl)-4,4'-bispyridiniumdiperchlorate;
1,1'-dimethyl-2-phenyl-4,4'-bispyridiumdiperchlorate;
6-(phenyl)-1,1',2-trimethyl-4,4'-bispyridiumdiperchlorate;
1,1'-dimethyl-2-phenyl-6-(2,5-dichloro-3-thienyl)-4,4'-bispyridiumdiperchlorate.

20. Use of bispyridinium compounds having the general formula (I) or (Ib) as a functional unit in memory units.